ASL 5000 Breathing Simulator
Test Automation Interface (TAI)
Software Specification Document

V7.0

February 19, 2015

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Revision History

Revision Number	*Revision Date*	*Summary of Changes*	*By*
2.0	*October 5, 2012*	• *Change document title to "Test Automation Interface"* • *Replace "Concept" with "Project Summary"* • *Added "General Server Information" section to define icon / server details* • *Updated "TCP Communications Protocol"* • *Expanded on "Command List Definitions" section* • *Added/Updated command list and formats*	*Bails*
3.0	*October 15, 2012*	• *Minor change to "Project Summary"* • *Updated "General Server" details (icon representation)* • *TCP sample header with code* • *Update to "Command List Definitions"* • *Default for enum on "Closed Loop" and "PCASECO2"* • *Corrected TC command* • *Added section "Error Codes and Definitions"*	*Bails*
4.0	*October 25, 2012*	• *Inserted Table of contents* • *Updated "Project Summary"* • *Updated graphic under "Project Summary"* • *Introduced colored icon representing the server status* • *Updated "TCP Communication Protocols"* • *Added definition of TCP Broadcast protocol* • *Updated COM port support to be COM1…COM8* • *Minor changes to "Command Structure"* • *Corrected ID parameter of OA command* • *Corrected PATH parameter of OA command* • *Updated PATH parameter of SF and RS commands* • *Added additional error codes*	*Schorn*
4.1	*December 4, 2012*	• *Added parameter GUI for OA command* • *Added "note" for default path of OA command with impending ASL 5000 Software update to 3.4* • *Corrected grammatical error of IC details* • *Added 10 "read-only" parameters to TC command* • *Added QT command to allow end-user to completely quit the TAI server* • *Added additional error codes* • *Changed LOOP and PCASECO2 values of IC command to be more descriptive*	*Bails / Schorn*
5.0	*January 11, 2013*	• *Placed commands in alphabetical order* • *Improved details about each command and*	*Bails / Schorn*

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		reference to ASL 5000 software GUI location relevant to commands • *Added AC – Auxiliary Compensations command* • *Added BP – Breath Parameters command, including all 83 available parameters with necessary conditions* • *Added BW – Breath Waveform command for downloading individual breath waveforms in tab-delimited text file* • *Added PS – Pause Simulation command for invoking pause.vr3 while running the TAI* • *Updated the TC command with SIM_VARFILE* • *Added error code 18 – Parameter out of range* • *Update error codes 13 and 14 with more details*	
5.1	*January 22, 2013*	• *Updated TO parameter of IC command* • *Updated "Success" description of IC command*	*Schorn*
5.2	*February 19, 2013*	• *Remove Breath_port and Wave_port from OA command* • *Add SC command for server configuration (breath and waveform clients) including Breath_port and Wave_port from OA command* • *Add error code 19 (firmware mismatch) and 20 (.vr3 file script erro)*	*Bails*
5.3	*February 20, 2013*	• *Update Project Summary* • *Update TCP Client (RAW versus PROC)*	*Bails*
5.4	*October 8, 2013*	• *Spelling corrections (BD, BW)* • *Definition correction p.9*	*Bails*
6.0	*January 25, 2014*	• *Update commands with sw 185 and TAI 130* • *Add default values for all command parameters (if applicable)*	*Bails*
7.0	*February 19, 2015*	• *Update name of document to TAI Specification X.X.pdf* • *Add IngMar Part Number (80 31 100)* • *Update to fit corporate identity* • *Update page reference for SC command* • *Add (Future) to right-click capabilities* • *Update TCP waveform table for RAW and PROC* • *Correct for 3.5 examples* • *Updated IC images to reflect 3.5.0.46 release build* • *Added RT_OUT, R1_OUT and R2_OUT as future updates (Build 139)* • *Added PAUSE to ICP Lung Parameters*	*Morgan/ Bails*

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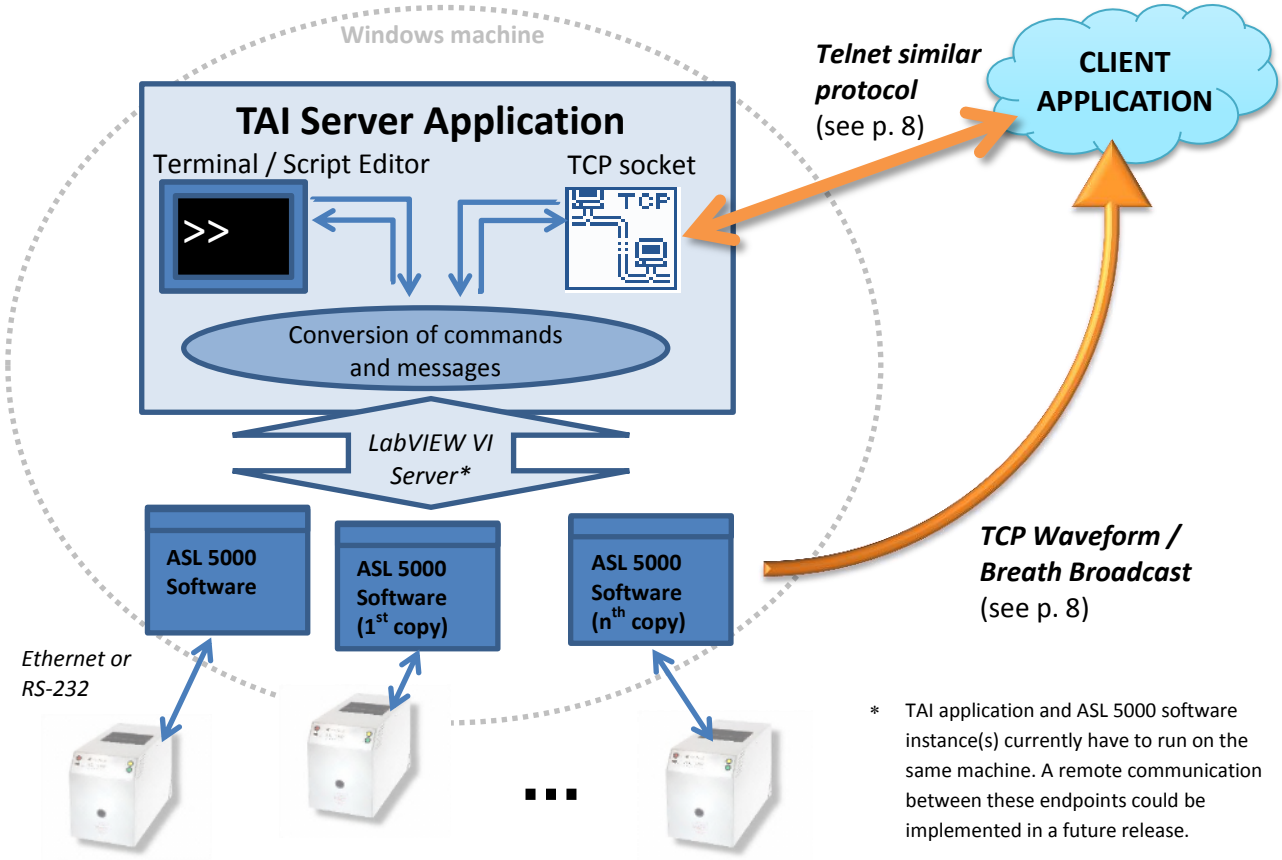
ASL 5000 Breathing Simulator

IngMar Medical Ltd. has developed an interface for the ASL 5000 breathing simulator, which will provide the end user with the capacity to incorporate the ASL 5000 into automation testing.

This server software will run independently from the ASL 5000 software and provides a command-based interface for the ASL 5000 control. The server will run in the background with a visible icon in the Windows task bar notification area. It can be accessed remotely or locally by connecting to a TCP/IP port and sending ASCII formatted commands.

For controlling the ASL 5000(s) the server can, as an option, open the ASL 5000 software in "hidden mode" which prevents unwanted user interference through the graphical interface (GUI) of the ASL 5000 software. GUI can still be made visible if needed (see OA command). The Server also has the capacity to run multiple instances of ASL 5000 systems through additional copies of the ASL 5000 Software package on the same CPU running the Server.

The remote interface will directly communicate with the ASL 5000 software. Third party users can create external applications in any independent language (C#, C++, VB, LabVIEW, etc.) to communicate with the server protocol via TCP connection. It is also possible to use an existing Telnet client (e.g. PuTTY) to connect to the server. Furthermore, a server internal terminal with script editor will be developed (future) for the creation and execution of predefined command scripts.



* TAI application and ASL 5000 software instance(s) currently have to run on the same machine. A remote communication between these endpoints could be implemented in a future release.

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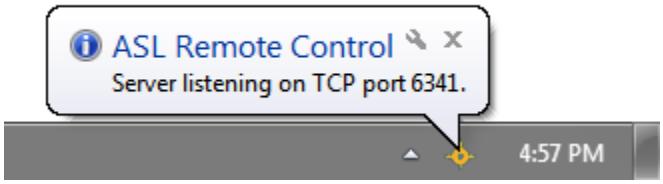
General Server Information

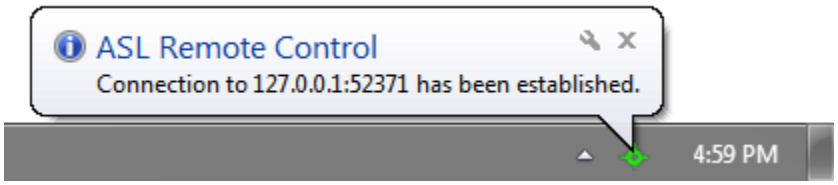
When the remote server is started, the server's icon will be visible in the bottom right (notification) area of the windows-based pc (tested on Win7 and WinXP systems). The icon's color will represent the current server status.
The following colors are possible:

(orange)	*Server is waiting for a connection*
(green)	*Server connected to a client*
(red)	*Server in error state*
(gray)	*Server initializing or stopped (by user)*

The Server pop-up provides information related to listening on the default ***TCP Port 6341.*** *This port can be changed by the user by right-click the icon (Future).*



The Server also provides a pop-up response to the user that a connection has been established and to which IP address. In this example, the Server has connected to the localhost IP address, 127.0.0.1.



By right clicking on the Server icon, the end-user can configure the server application with the following options (FUTURE):

- *Running ASL 5000 Instances*
  - *Provides details on each ASL 5000 instance that is running and controlled by the server (if applicable)*

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- *Network Interface*
    - *Provides a listing of all relevant IP addresses of the host computer (based on local area connections, wireless connections, and localhost)*
    - *Option of "All" will listen on all interfaces for a connection*
- *TCP Port*
    - *Port for the TCP connection to the server. Default port is **6341**. The end user has the ability to change the TCP port. User should make sure that other processes are not using any other defined port before changing from the default port.*
    - *As a safeguard, the server checks to see if the user-defined port is already in use by another operation. If so, server will report an error and automatically resume with the default port of **6341**.*
- *Status*
    - *Provides server connection status:*
        - *Waiting for connection*
        - *Connected to IP address (with address visible)*
        - *Stopped*
        - *Error (TBD)*
        - *Initializing (only during startup of the server)*
- *Start / Stop / Disconnect Server*
    - *The options below are available depending on the state of the server*
        - *Stop – server no longer listens on port 6341 (or user defined)*
        - *Start – Start listening for a connection on port 6341 (or user defined)*
        - *Reset server (re-initialize server settings – defaults to port 6341)*
- *Launch Terminal (future)*
    - *Provides user with command-line control via terminal connection*
    - *Ability to load / test scripts and automation options by end user before implementing full automation process*
- *Exit*
    - *Closes server connection and exits server (removes icon)*

NOTE: ONLY ONE CLIENT CAN CONNECT TO THE SERVER AT A TIME, HOWEVER, THE CLIENT CAN CONTROL MULTIPLE INSTANCES OF THE ASL 5000 SOFTWARE BASED ON THE UNIQUE IDENTIFIER OF EACH ASL 5000 (SEE DETAILS BELOW)

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Communication with the TAI Server

The communications protocol is based on sending and receiving terminated ASCII strings over a TCP connection. Incoming and outgoing messages have to be terminated by the sequence CR LF (carriage return and line feed characters), which is hexadecimal 0D 0A. Since this conforms to the Telnet End-of-Line convention, it is possible to use any regular Telnet client software to communicate with the server. IngMar Medical has verified that the software PuTTY (freeware) is working together with the TAI server.

To open a session, the client has to connect to the IP address and TCP port the server is listening on. These values can be configured in the server menu (see above). The client will receive a command prompt immediately after the connection has been established.

Receiving the TCP Waveform and Breath Parameter Broadcasts

*The TCP Waveform and Breath Parameter Broadcasts have been part of the ASL 5000 software since version 3.0 and can be used independently from the TAI server. To receive the current breath parameters the user can connect to the **TCP port 6342** on the IP address of the machine the ASL 5000 software is running on. Waveforms are published on **TCP port 6343**. Using the SC command of the TAI server (see page 27), it is possible to change these default values (e.g. if multiple instances of the ASL 5000 software are used at the same time).*

The broadcast messages are sent in ASCII format and are prefixed with a 32-bit signed integer header equal to the size of the message (excluding the header itself). The byte order is Big Endian (Network Order). The messages itself have the following structure:

Breath Parameters (sent after each breath):

Descriptor (field width 40, filled with spaces)	*TAB (x09)*	*Parameter Value*	*CR (x0D)*	*LF (x0A)*
…	…	…	…	…
…	…	…	…	…

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Waveforms (sent continuously with timestamp):

First row: *Tab delimited column headers*
Following rows: *Tab delimited values*

RAW Waveforms based on ASL 5000 Analog signals. Flow is not included as it is a calculated value

Airway Pressure (cmH2O)	*Muscle Pressure (cmH2O)*	*Tracheal Pressure (cmH2O)*	*Chamber 1 Volume (mL)*	*Chamber 2 Volume (mL)*	*Total Volume (mL)*	*Chamber 1 Pressure (cmH2O)*	*Chamber 2 Pressure (cmH2O)*	*BreathFile Number (#)*	*Aux 1 (V)*	*Aux 2 (V)*	*Oxygen Sensor (V)*	*Breath Detection (#)*

PROCESSED Waveforms based on calculated parameters and can be adjusted for volume compensations (e.g. BTPS, ATPD, etc.)

Airway Pressure (cmH2O)	*Muscle Pressure (cmH2O)*	*Tracheal Pressure (cmH2O)*	*Chamber Volume 1 (mL)*	*Chamber Volume 2 (mL)*	*Total Volume (mL)*	*Chamber 1 Pressure (cmH2O)*	*Chamber 2 Pressure (cmH2O)*	*Chamber 1 Flow (L/min)*	*Chamber 2 Flow (L/min)*	*Total Flow (L/min)*

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Command Prompt Structure

The server provides a command-line prompt methodology consisting of 10 characters as defined in the table below:

Character #	*Definition*	*Notes*
1	*Prompt type*	*a.* ***>*** *input prompt* *b.* ***<*** *response prompt* *c.* ***!*** *error prompt* *d.* ***#*** *comment prompt*
2-4	*Required 3-letter "**ASL**" definition*	*Always included in prompt as "**ASL**"*
5-8	*Connection identity - unique identifier of ASL 5000 system(s)*	*a. Ethernet connection = serial number of the ASL 5000 hardware* *b. Serial connection = COM port used by unique ASL 5000 (this must be defined by the end user). **Available ports are COM1 to COM8 ONLY*** *c. Demo mode =The word "**DEMO**" will be added to the prompt when in the ASL 5000 software demo mode (no connection to ASL 5000 hardware)* *d. All systems connection = connection to all system that the server will control, "**0000**"will be visible in this field*
9	*Completion of prompt*	*Always included in the prompt is a colon "**:**"*
10	*" ␣ " Space before user data*	*Always included in the prompt is a space before the user command is entered*

Example prompts:

*>ASL1234: ␣ Ethernet connection **input prompt** ASL 5000 s/n 1234 – input command line*

*<ASLCOM2: ␣ Serial connection **response prompt** to ASL 5000 with COM2 active – response command line*

*!ASLDEMO: ␣ Demo mode with an **error prompt***

*#ASL0000: ␣ **Comment prompt** related to controlling all ASL 5000's connected to the server*

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Command Structure

*All command inputs are case **in**sensitive. All responses are in capital letters (including the prompt).*

Each command consists of two letters, which define the command operation. If the command needs input arguments, it is followed by a space and additional arguments are space separated. Some arguments are optional.

>ASLxxxx:␣ command <mandatory parameter(s)=value> [optional parameter(s)=value]

All parameter fields are in the form x=y.

If there were a "space" within a parameter value, the user must surround the value in quotation marks, for example, to open the ASL 5000 software in demo mode from a specific path, the command would read:

>ASLxxxx: OA id=demo path="c:\Program Files (x86)\ASL Software 3.5\ASL 5000_SW3.5.exe"

All input statements will generate a response from the server. If the command is successful, the response is an echo of the initial input statement. If the command fails, the response is an error statement with an error code and explanation. Following the response, the user will receive a new prompt.

Example with valid input and response:

Input ->	*oa id=demo path="C:\Program Files\ASL Software 3.5\ASL 5000_SW3.5.exe"*
Response ->	*<ASLDEMO: OA ID=DEMO PATH=C:\PROGRAM FILES\ASL SOFTWARE 3.5\ASL 5000_SW3.5.EXE*
New prompt ->	*>ASLDEMO:*

Example with invalid input and error:

Input ->	*oa id=foo*
Response ->	*!ASL0000: ERROR(05) OA: INVALID PARAMETER 'ID'.*
New prompt ->	*>ASL0000:*

*The response will not be sent until the execution of the command is finished. However, if the execution takes for some reason longer than expected, there will be a message with a timeout error sent after a specific time. All commands have a default timeout value (TO or to). If the timeout occurs, the command will have no effect. The client application must, in any case, wait for a return message before issuing the next command, because commands are synchronous and will not be buffered. To remove a timeout value, set TO=0. This is **NOT** recommended, as the server will continue to try implementing a command even if there is a failure. Also, the timeout message will not be received exactly after TO milliseconds, but with a slight delay due to internal processing time (future work may correct this).*

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Monitoring Parameter Values

User can monitor / verify / check the status or value of any command parameter. This is accomplished using the same x=y format, instead replacing the "y" with a "?", for example:

Input -> *>ASLxxxx: ic rt=?*

Response -> *<ASLXXXX: IC RT=5.000000*

The monitor capability can also work in tandem with an input parameter command, for example:

Input -> *>ASLXXXX: ic rt=? c1=50*

Response -> *<ASLXXXX: IC RT=5 C1=50*

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< > Mandatory Parameters [ ] Optional Parameters

AC – Auxiliary Compensation Parameters

Resistance and compliance parasitics in ventilator volume calculations

ASL 5000 GUI – IngMar Medical ASL 5000: Breath Detection / RT – Analysis Window

AC [C] [EXP_R] [INSP_R] [TO]

C	Auxiliary circuit compliance [mL/cmH2O], default=0.00
EXP_R	Auxiliary expiratory circuit resistance [cmH2O/L/s], default=0.00
INSP_R	Auxiliary inspiratory circuit resistance [cmH2O/L/s], default=0.00
TO	Time out [ms], default=10000

Success: Parameters changed

BD – Breath detection settings

Trigger settings for reading a breath

ASL 5000 GUI – IngMar Medical ASL 5000: Breath Detection / RT – Analysis Window

BD [INSP_T] [EXP_T] [EFF_T] [TO]

INSP_T	Inspiratory Threshold [mL] for detecting the start of the inspiratory phase, default=5.00mL
EXP_T	Expiratory Threshold [mL] for detecting the end of the expiratory phase, default=5.00mL
EFF_T	Patient Effort Threshold [cmH2O], default=-0.1cmH2O
TO	Time out [ms], default=10000

Success: Parameters changed

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BP – Breath Parameters

ASL 5000 breath parameters calculated for analysis, including gas/temperature conditions and precision. Parameter definitions can be found in the ASL 5000 User's Manual. The left column is the TAI command parameter. The right column is the parameter as defined in the ASL 5000 User's Manual and in the Breath Detection / RT – Analysis drop-down boxes.

ASL 5000 GUI – IngMar Medical ASL 5000: Breath Detection / RT - Analysis

BP [Parameter Name1=?] [Parameter Name2=?]…[Parameter NameN=?] [TO]

READ and WRITE Parameters	
General Parameters	
NAME	Simulation output file name, which is defined by the RS command, default = data
BREATH_NUM	Breath Number **n** of **m** total breaths (where **m** is defined by BREATH_COUNT). Negative numbers count backwards from the most recent breath, default = -1
PREC	Precision of parameter output (number of digits to the right of the decimal point), default = 6
COND	Gas and Temp conditions: • AM – as measured (default) • BTPS – Body Temperature Pressure Saturated • STPD – Standard Temperature and Pressure, Dry • SPD – Standard Pressure, Dry at T=20°C • ATPD – Ambient Temperature and Dry Pressure
PATH	Path where [NAME] files will be saved. Can be relative to the path defined by the OA command ('\' prefix has to be used). Default path is: • \ASLdata
TO	Time out [ms], default = 10000
READ ONLY Parameters	
Breath Parameters	
BREATH_TYPE	Breath Type
BREATH_INSP_TYPE	Insp Breath Type
BREATH_COUNT	Total breaths in a simulation
Time Parameters	
TIME_BR	Breath Rate [BPM]
TIME_INSP	I Time [s]
TIME_INSP_PERCENT	Insp %
TIME_PAUSE	Pause Time [s]
TIME_PAUSE_PERCENT	Pause %
TIME_EXP	E Time [s]
TIME_IE_RATIO	I/E
TIME_TRIG_RESP	Trig Resp Time [ms]
TIME_SOE_TO_PMIN	Time to Pmin after Start of Effort [ms]
TIME_PMIN_TO_PEEP	Time between Pmin and PEEP [ms]

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TIME_T90_INSP	Insp T90 [ms]
TIME_T90_EXP	Exp T90 [ms]
TIME_SETTLING_INSP	Insp Settling Time [ms]
TIME_SETTLING_EXP	Exp Settling Time [ms]
Flow Parameters	
FLOW_PEAK	Peak Flow [L/min]
FLOW_MEDIAN	Median Flow [L/min]
FLOW_MEAN	Mean Flow [L/min]
FLOW_ACC_MAX	Max Flow Acc [L/s**2]
FLOW_ACC_MIN	Min Flow Acc [L/s**2]
FLOW_PERC_OF_PEAK_AT_SOE	Perc of Peak Flow at Start of Exp [%]
Pressure Parameters	
P_PEAK	P_peak [cmH2O]
P_MIN	P_min [cmH2O]
P_PAUSE	P_pause [cmH2O]
P_MEAN	P_mean [cmH2O]
P_MEAN_INSP	P_mean Insp [cmH2O]
P_MEAN_EXP	P_mean Exp [cmH2O]
P_MEAN_1	P_mean Ch 1 [cmH2O]
P_MEAN_1_INSP	P_mean Ch1 Insp [cmH2O]
P_MEAN_1_EXP	P_mean Ch1 Exp [cmH2O]
P_MEAN_2	P_mean Ch2 [cmH2O]
P_MEAN_2_INSP	P_mean Ch 2 Insp [cmH2O]
P_MEAN_2_EXP	P_mean Ch2 Exp [cmH2O]
P_PEEP	PEEP [cmH2O]
P_PEEP_AUTO_1	Auto-PEEP 1 [cmH2O]
P_PEEP_AUTO_2	Auto-PEEP 2 [cmH2O]
P_PEEP_TOTAL_1	Total PEEP 1 [cmH2O]
P_PEEP_TOTAL_2	Total PEEP 2 [cmH2O]
P_DROP_MAX_DURING_TRIG	Max Pres Drop During Trig [cmH2O]
P_TARGET_INSP	Insp Target [cmH2O]
P_TARGET_EXP	Exp Target [cmH2O]
P_OVERSHOOT_PERC_INSP	Insp Overshoot [%]
P_OVERSHOOT_PERC_EXP	Exp Overshoot [%]
P_MEAN_SQ_ERROR_INSP	Insp Mean Sq Error [cmH2O**2]
P_MEAN_SQ_ERROR_EXP	Exp Mean Sq Error [cmH2O**2]
Volume Parameters	
VOL_PAT_VT_INSP	Patient Insp Vt [mL]
VOL_PAT_VT_EXP	Patient Exp Vt [mL]
VOL_PAT_VT_1	Patient Vt 1 [mL]
VOL_PAT_VT_2	Patient Vt 2 [mL]
VOL_VENT_VT_INSP	Vent Insp Vt [mL]
VOL_VENT_VT_EXP	Vent Exp Vt [mL]
Resistance Parameters	
RES_EXP_SD	SD Exp Res [cmH2O/L/s]
RES_EXP_MEDIAN	Median Exp Res [cmH2O/L/s]

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Work Parameters	
WORK_PAT_INSP	Pat Insp Work [mJ]
WORK_PAT_INSP_ELAST	Pat Insp Elastic Work [mJ]
WORK_PAT_INSP_RES	Pat Insp Res Work [mJ]
WORK_PAT_TRIG_TO_PEEP	Pat Trig Work to PEEP [mJ]
WORK_PAT_SOE_TO_PMIN	Pat Trig Work SoE to P_min [mJ]
WORK_PAT_PMIN_TO_PEEP	Pat Trig Work P_min to PEEP [mJ]
WORK_PAT_EXP	Pat Exp Work [mJ]
WORK_PAT_EXP_ACT	Pat Exp Active Work [mJ]
WORK_PAT_EXP_RES	Pat Exp Res Work [mJ]
WORK_PAT_HEAT_PROD	Pat Heat Production [mJ]
WORK_PAT_RES	Pat Total Res Work [mJ]
WORK_EXT_INSP	Ext Insp Work [mJ]
WORK_EXT_INSP_ELAST	Ext Insp Elastic Work [mJ]
WORK_EXT_INSP_RES	Ext Insp Res Work [mJ]
WORK_EXT_EXP	Ext Exp Work [mJ]
WORK_EXT_EXP_ACT	Ext Exp Active Work [mJ]
WORK_EXT_EXP_RES	Ext Exp Res Work [mJ]
WORK_EXT_HEAT_PROD	Ext Exp Heat Production [mJ]
WORK_TOT_INSP	Total Insp Work [mJ]
WORK_TOT_INSP_ELAST	Total Insp Elastic Work [mJ]
WORK_TOT_INSP_RES	Total Insp Res Work [mJ]
WORK_TOT_EXP	Total Exp Work [mJ]
WORK_TOT_EXP_ACT	Total Exp Active Work [mJ]
WORK_TOT_EXP_RES	Total Exp Res Work [mJ]
WORK_TOT_HEAT_PROD	Total Heat Production [mJ]
WORK_TOT_RES	Total Res Work [mJ]
WORK_PAW_TIME_PROD	P_aw Time Product [cmH2O*ms]
WORK_PAW_TIME_PROD_TRIG	P_aw Time Product Trig [cmH2O*ms]
WORK_PAW_TIME_PROD_300	P_aw Time Product 300 [cmH2O*ms]
WORK_PAW_TIME_PROD_500	P_aw Time Product 500 [cmH2O*ms]
WORK_PMUS_TIME_PROD	P_mus Time Product [cmH2O*ms]
Environment / Analog Parameters	
ENV_P_BARO	P_baro (kPa)
ENV_T_AMBIENT	Ambient Temp [C]
ENV_T_WALL	Wall Temp [C]
ENV_OXYGEN	Oxygen [%]
ENV_AUX_1	Aux 1 [V]
ENV_AUX_2	Aux 2 [V]

Success: Parameters changed

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BW – Breath Waveform

Offload waveform file in tab-delimited format.

ASL 5000 GUI – IngMar Medical ASL 5000: Post Run Analysis Menu

BW [NAME] [BREATH_NUM] [PREC] [COND] [PATH] [OUTNAME] [OUTPATH] [SIM_TIME] [TO]

NAME	Name for recorded data from RS command, default=data
BREATH_NUM	Breath Number **n** of **m** total breaths (where **m** is defined by BREATH_COUNT). Negative numbers count backwards from the most recent breath, default = -1
PREC	Precision of parameter output (number of digits to the right of the decimal point), default = 6
COND	Gas and Temp conditions: • AM – as measured (default) • BTPS – Body Temperature Pressure Saturated • STPD – Standard Temperature and Pressure, Dry • SPD – Standard Pressure, Dry at T=20°C • ATPD – Ambient Temperature and Dry Pressure
PATH	Path where [NAME] files will be saved. Can be relative to the path defined by the OA command ('\' prefix has to be used). Default path is: • \ASLDATA
OUTNAME	Output file name for tab delimited file, default=BW_OUTPUT
OUTPATH	Path where [OUTNAME] file will be saved. Default path is: • \ASLDATA
SIM_TIME	Time stamp to be relative to the individual breath (default) or relative to the overall simulation time. Default = FALSE
TO	Time out [ms], default = 10000

Success: Parameters changed

ES – End simulation

Ends the current simulation

ES [TO]

TO	Time out [ms], default=10000 **NOTE**: Linked to directly to Simulation button on Central Run Time Display

Success: Simulation ended and ASL 5000 stopped

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EX – Exit ASL 5000 software

Exit the ASL 5000 software

EX [TO]

TO	Time out [ms], default=10000 **NOTE:** Linked directly to Exit ASL 5000 Button

Success: ASL 5000 software closed

IC – Interactive Control

Interactively write and read parameters during simulation (***IM command must be invoked***)

ASL 5000 GUI – IngMar Medical ASL 5000: Interactive Control Panel Window

IC [parameter1=value1] [parameter2=value2] … [parameterN=valueN] [TO]

ParameterNAME = ParameterVALUE	There are several parameters within the Interactive Panel, which are detailed below. The tabs in the Interactive Control Panel are based on the patient type and the loop model defined by the user.
	
	The open and closed loop options are defined as follows:
	• No Loop
	  ○ Based on the pre-defined patient model
	• Constant MV Loop
	  ○ Based on adjusting parameters to maintain a set Minute ventilation
	• Constant Vt Loop
	  ○ Based on adjusting parameters to maintain a set Tidal Volume
	• CO2Y Loop
	  ○ Based on adjusting parameters to attain a simulated set $EtCO_2$
	
	Parameters vary depending on the loop defined. In all cases, the spontaneous parameters and the breath parameters can be adjusted

TO	Time out [ms], default=60000

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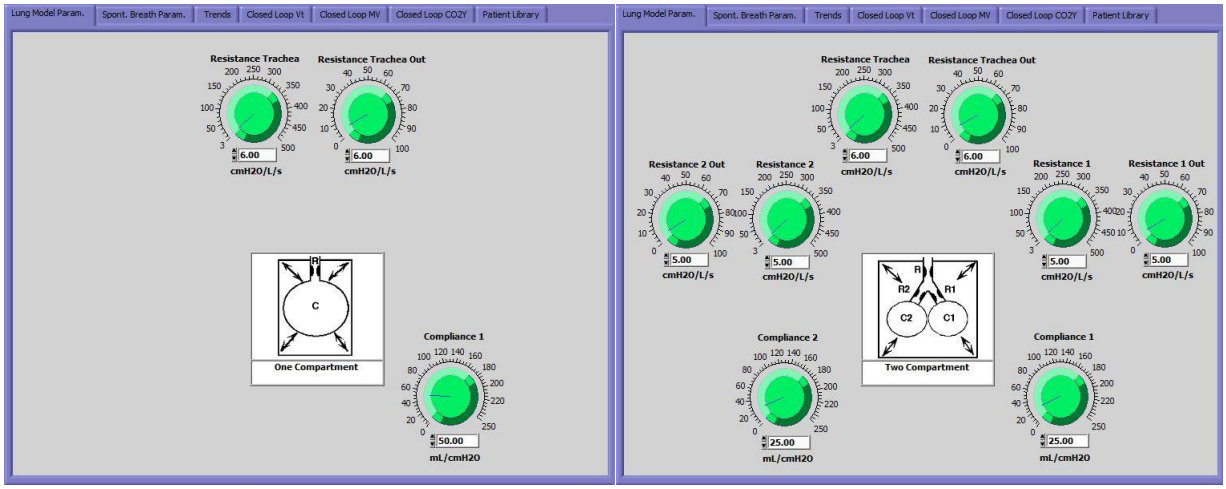
Loop Control Parameters:

LOOP	Closed Loop Control • LOOP=NO_LOOP No Loop (default) • LOOP=CONST_VT Constant Vt Loop • LOOP=CONST_MV Constant MV Loop • LOOP=CO2Y CO2Y Loop

Lung Model Parameters:



Single and Dual Lung Models ***RT***	Tracheal Resistance [cmH2O/L/s], default=predefined lung model
Single and Dual Lung Models ***RT_OUT***	Exp. Tracheal Resistance [cmH2O/L/s], default=predefined lung model (future)
Single and Dual Lung Models ***C1***	Lung Compliance [mL/cmH2O], default=predefined lung model. For single lung model, this is the total lung compliance (based on model above left). For a dual lung model, this is the left lung compliance
Dual Lung Model ***C2***	Lung Compliance [mL/cmH2O] of the right lung
Dual Lung Model ***R1***	Lung Resistance [cmH2O/L/s] of the left branch
Dual Lung Model ***R2***	*Lung Resistance [cmH2O/L/s] of the right branch*
Dual Lung Model ***R1_OUT***	Exp. Lung Resistance [cmH2O/L/s] of the left branch (future)
Dual Lung Model ***R2_OUT***	Exp. Lung Resistance [cmH2O/L/s] of the right branch (future)

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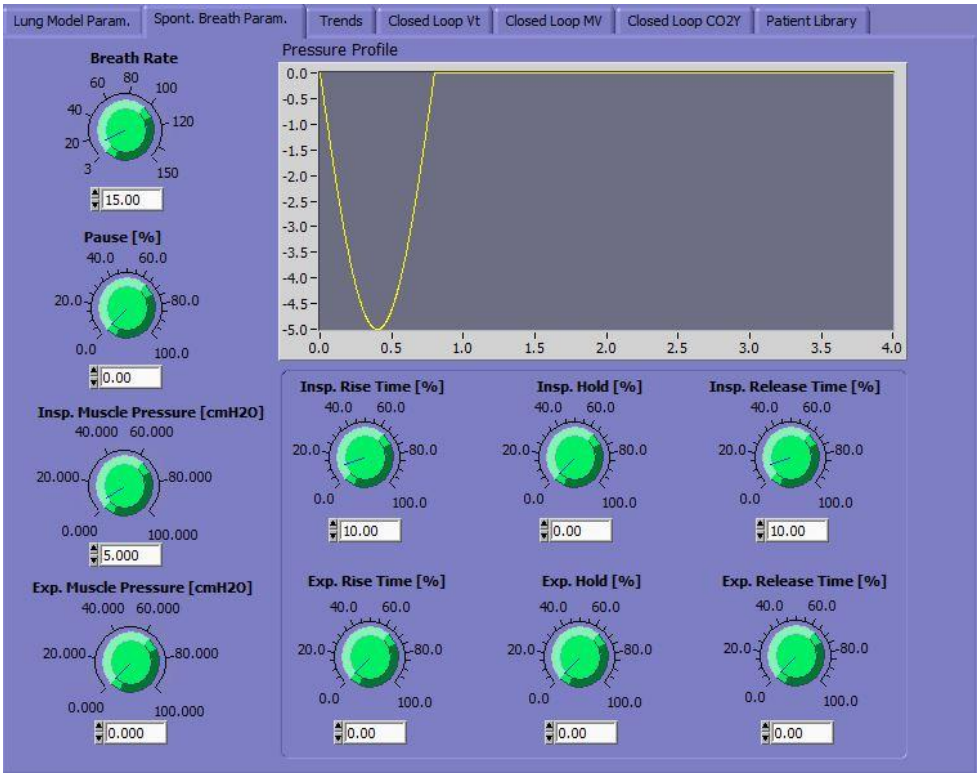
Spontaneous Breath Parameters



RATE	Breath Rate [bpm]
PAUSE	Pause between Insp. and Exp. Muscle Pressure [%]
INSP_PMUS	Insp. Muscle Pressure [cmH2O]
INSP_RISETIME	Insp. Rise Time [%]
INSP_HOLD	Insp. Hold [%]
INSP_RELEASETIME	Insp. Release Time [%]
EXP_PMUS	Exp. Muscle Pressure [cmH2O]
EXP_RISETIME	Exp. Rise Time [%]
EXP_HOLD	Exp. Hold [%]
EXP_RELEASETIME	Exp. Release Time [%]
TRIGGERTIME	Trigger time [ms] for pressure and flow trigger simulations (not pictured above)

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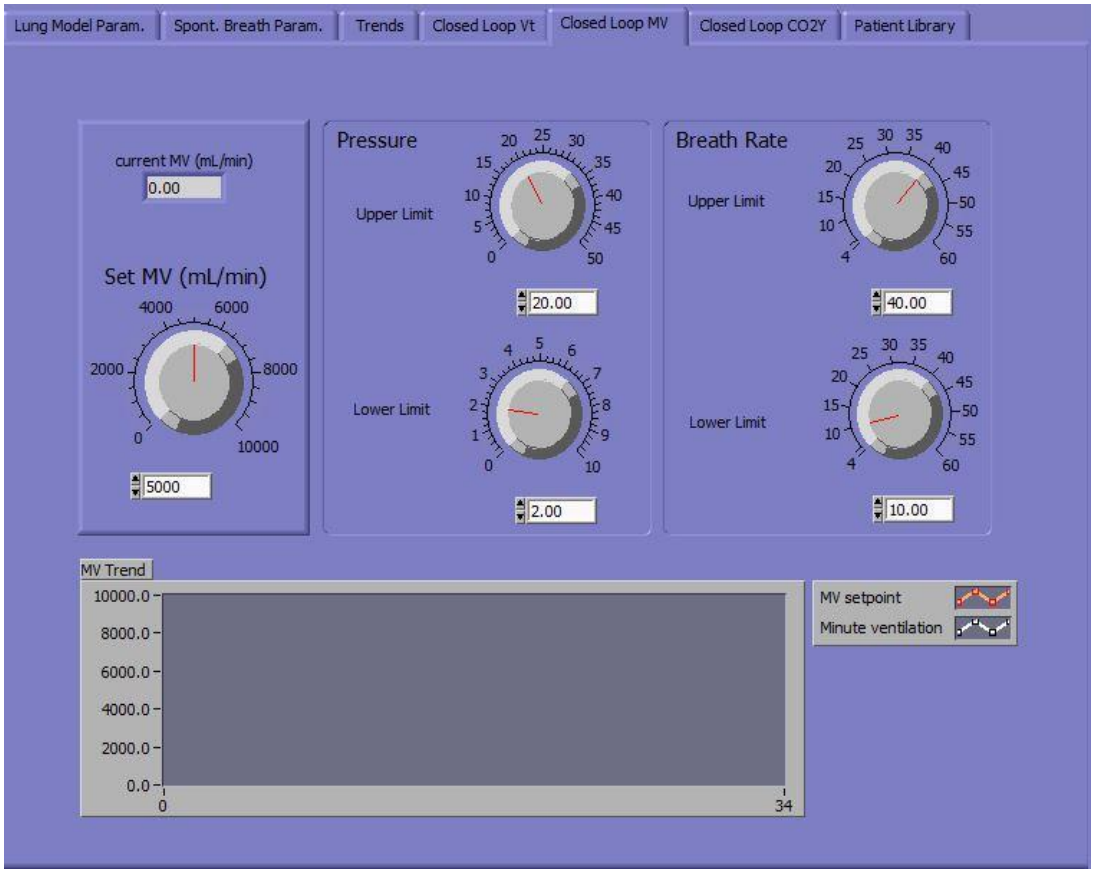
LOOP=CONST_MV Loop Parameters:



MVSET	Set Minute Ventilation [mL/min] for closed loop simulation
PMVUPPER	Upper pressure limit [cmH2O] for Minute Ventilation closed loop simulation
PMVLOWER	Lower pressure limit [cmH2O] for Minute Ventilation closed loop simulation
FMVUPPER	Upper limit breaths rate [bpm] for Minute Ventilation closed loop simulation
FMVLOWER	Lower limit breath rate [bpm] for Minute Ventilation closed loop simulation

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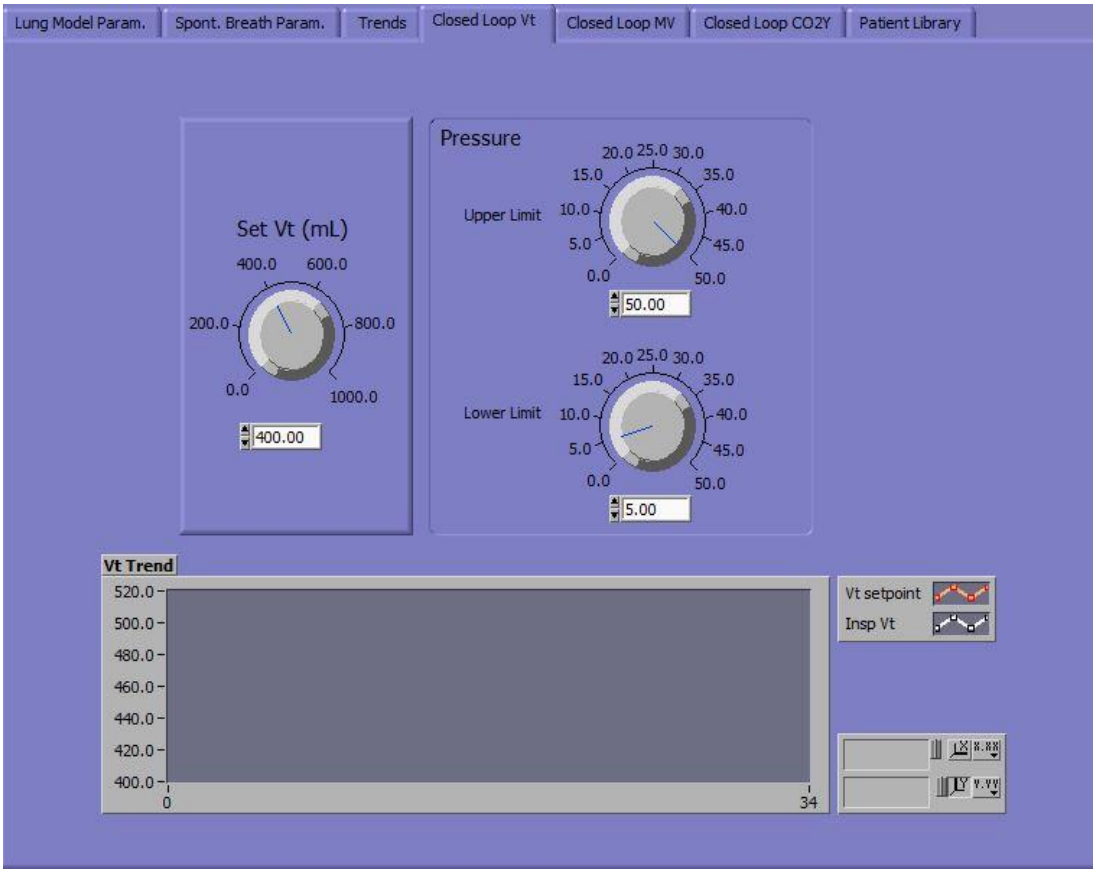
LOOP=CONST_VT Loop Parameters



VTSET	Set Tidal Volume [mL] for closed loop simulation
PVTUPPER	Upper pressure limit [cmH2O] for Tidal Volume closed loop simulation
PVTLOWER	Lower pressure limit [cmH2O] for Tidal Volume closed loop simulation

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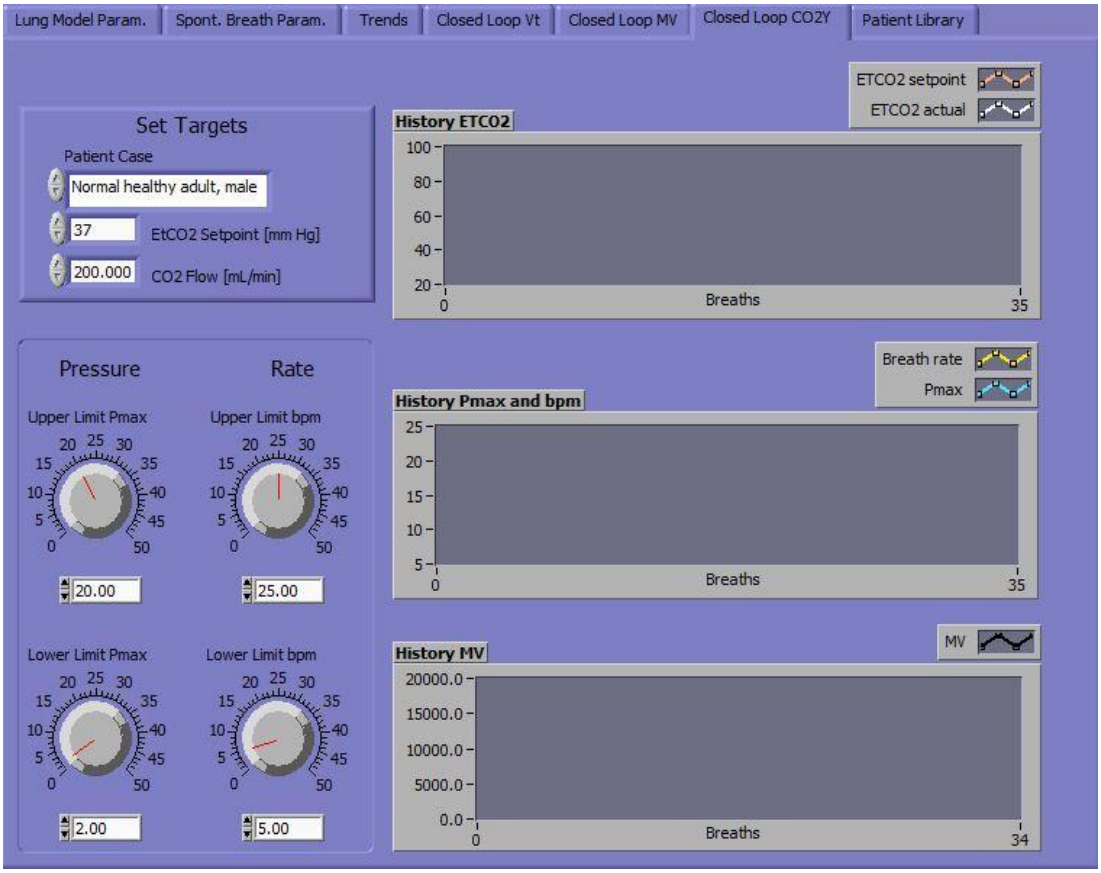
LOOP=CO2Y Loop Parameters



PCASECO2	Selected patient target case for CO2Y Closed Loop: • NORMAL = Normal healthy adult, male • COPD_III = COPD Severity code III • USER = User appointed patient • PULM_FIB = Pulmonary Fibrosis
ETCO2SET	EtCO2 setpoint [mm Hg] for CO2Y closed loop simulation
CO2FLOW	CO2 flow [mL/min] for CO2Y closed loop simulation
PCO2UPPER	Upper pressure limit [cmH2O] for CO2Y closed loop simulation
PCO2LOWER	Lower pressure limit [cmH2O] for CO2Y closed loop simulation
FCO2UPPER	Upper limit breaths rate [bpm] for CO2Y closed loop simulation
FCO2LOWER	Lower limit breath rate [bpm] for CO2Y closed loop simulation

Success: Values changed (software must be in IM). Return string will list the current values of the affected parameters in the same order as in the command. The response is sent out immediately after the new settings take effect in the simulation.

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IM – Interactive Mode

Invoke Interactive Mode (allows user to issue IC commands for interactive control of the simulation)
ASL 5000 GUI – IngMar Medical ASL 5000: Central Run Time Display Window

IM [TO]

TO	Time out [ms], default=10000

Success: Interactive mode entered (script file mode left)

OA – Open ASL 5000 Software Instance (*IngMar Medical ASL 5000: Welcome* Window)

Open an instance of the ASL 5000 software. The OA command can be run as many times as needed as long as user uses a different path (e.g. ASL Software 3.5 A, ASL Software 3.5 B, etc.)
ASL 5000 GUI – IngMar Medical ASL 5000: Welcome Window

OA <ID> [PATH] [GUI] [TO]

ID	*For Ethernet connection: 4-digit serial number of the ASL 5000 (e.g. ID=0123)* *For Serial connection: Port the ASL 5000 is connected to (e.g.ID=COM1). COM1 to COM8 are supported.* *For demo mode: ID=DEMO*
PATH	*Path to ASL 5000 software executable. If omitted, default path is:* • *32bit - c:\Program Files\ASL Software 3.5* • *64bit – c:\Program Files (x86)\ASL Software 3.5* ***NOTE: The release version of the TAI server will be in tandem with ASL 5000 Software 3.5, thus the default path will end with:*** ***…\…\ASL Software 3.5***
GUI	*GUI=0 hides the graphical user interface of the ASL 5000 Software (default)* *GUI=1 shows the graphical user interface of the ASL 5000 Software*
TO	*Time out in [ms], default=30000*

Success: ASL 5000 software in “ready” condition

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PF – Pressure filter setting (*IngMar Medical ASL 5000: Breath Dection / RT – Analysis Window)*

Invoke a pressure filter of airway pressure recordings

ASL 5000 GUI – IngMar Medical ASL 5000: Breath Detection / RT – Analysis Window

PF [TYPE] [TO]

TYPE	Type of pressure filter used in the simulation: • 0 = None • 1 = 5 Hz Butterworth • 2 = Moving Average (default)
TO	Time out [ms], default=10000

Success: Pressure filter changed

PS – Pause Button Enable/Disable

Enable / Disable the pause.vr3 file during a simulation

ASL 5000 GUI – IngMar Medical ASL 5000: Central Run Time Display Window

PS [PAUSE] [TO]

PAUSE	Enable or disable the Pause button from the GUI: • 0 = Disabled (default) • 1 = Enabled (invokes pause.vr3) **NOTE:** The Pause button allows the user to initiate a "paused" breath pattern, which can be user defined. The pause.vr3 file defaults to a passive patient model, however, the user can change the pause.vr3 file. The Pause button is directly linked to pause.vr3 file.
TO	Time out [ms], default=10000

Success: Pause button enabled / disabled

QT – Completely close and quit the TAI server

Exit the TAI server including closing all ports

QT [TO]

TO	Time out [ms], default=10000

Success: The TAI server and the the terminal client (i.e. Putty) will close. The TAI icon will no longer be present in the task notification area.

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RS – Run Simulation

Start ASL 5000 simulation

ASL 5000 GUI – IngMar Medical ASL 5000: Central Run Time Display Window

RS [WF] [OW] [NAME] [PATH] [TO]

WF	Save waveforms, yes = 1, no = 0 (default)
OW	Overwrite if file exists, yes = 1, no = 0 (default)
NAME	Name for recorded data, default=data
PATH	Path where [NAME] files will be saved. Can be relative to the path defined by the OA command ('\' prefix has to be used). Default path is: • \ASLDATA
TO	Time out in [ms], default=10000

Success: Simulation running

SA – Select Unique ASL 5000 by ID

Select individual or all ASL 5000 instances to control

SA <ID> [TO]

ID	Identifier of ASL 5000 to control. This updates the terminal prompt and allows the user to run individual or broadcast commands to a single or multiple ASL 5000 units. *ID=1234* results in the Ethernet connected ASL 5000 with S/N 1234 to be controlled *ID=COM3* results in the Serial connected ASL 5000 on COM3 to be controlled *ID=0000* results in the ability to broadcast commands to all connected ASL 5000 units **NOTE: This command can only run after the OA command has been used to open a single or multiple instances of the ASL 5000 software**
TO	Time out [ms], default=10000

Success: Prompt changes to reflect current ASL 5000 hardware being controlled

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SC – Breath / Waveform Server Configuration

Configures the output configuration for the Breath and Waveform clients

SC [BREATH_PORT] [WAVE_PORT] [WAVE_TYPE] [COND] [PREC] [TO]

BREATH_PORT	*Port defined for TCP breath client, default=6342* *NOTE: Set ports to "0" to let system dynamically choose port number*
WAVE_PORT	*Port defined for TCP waveform client, default=6343* *NOTE: Set ports to "0" to let system dynamically choose port number*
WAVE_TYPE	*Type of data on output stream from waveform server* • *RAW – raw data waveform (no volume conditions), default* • *PROC – processed data based on volume conditions (COND)*
COND	Gas and Temp conditions: • AM – as measured (default) • BTPS – Body Temperature Pressure Saturated • STPD – Standard Temperature and Pressure, Dry • SPD – Standard Pressure, Dry at T=20°C • ATPD – Ambient Temperature and Dry Pressure
PREC	Precision of parameter output (number of digits to the right of the decimal point), default = 6 NOTE: Waveform timestamp will always be transmitted with high precision [15]
TO	Time out [ms], default=10000

Success: Prompt changes to reflect current ASL 5000 hardware being controlled

SF – Script File

Details about the script (.sct) file that will be used for simulation

ASL 5000 GUI – IngMar Medical ASL 5000: Simulation Script Editor Window

SF [NAME] [PATH] [TO]

NAME	Name of script file (ex. adult_normal or adult_normal.sct), default=CURRENT
PATH	Path to script file. Can be relative to the path defined by the OA command ('\' prefix has to be used). If omitted, default path is: • \VARS
TO	Time out in [ms], default=10000

Success: Script file was loaded

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SM – Script Mode

Enter script mode where the original script file is being used (same as exiting Interactive Control)
ASL 5000 GUI – IngMar Medical ASL 5000: Interactive Control Panel Window

SM [TO]

TO	Time out [ms], default=10000

Success: Script file mode entered (interactive mode left)

TC – Tell Condition

Provide the user diagnostic feedback from the TAI server

TC [ASL_STATUS] [SIM_STATUS] [SIM_MODE] [SIM_TIME] [SIM_TIME_REMAIN] [SIM_BREATH-SCT] [SIM_BREATH_CNT] [SIM_VARFILE] [SW_VERSION] [FW_VERSION] [TAI_VERSION] [TO]

<table>
<tr><td>ASL_STATUS</td><td>Current status of the ASL 5000 hardware unit (NOT YET IMPLEMENTED IN VERSION 5.0):
UNKNOWN (current response until next update)
Loss of communication
Large volume error
Oscillation error (chatter of the piston)
Over temperature
Sensor fault</td></tr>
<tr><td>SIM_STATUS</td><td>Status of the current simulation based on following table
<table>
<tr><th>SIM_STATUS</th><th>ERROR</th><th>Sim button</th><th>Pause button</th></tr>
<tr><td>IDLE</td><td>False</td><td>False</td><td>DC</td></tr>
<tr><td>RUNNING</td><td>False</td><td>True</td><td>False</td></tr>
<tr><td>PAUSED</td><td>False</td><td>True</td><td>True</td></tr>
<tr><td>ERROR</td><td>True</td><td>DC</td><td>DC</td></tr>
</table>
DC means “don’t care”</td></tr>
<tr><td>SIM_MODE</td><td>Displays which mode is being run by the simulation:
Script
Interactive
Unknown</td></tr>
<tr><td>SIM_TIME</td><td>Displays the elapsed time of the simulation in the following format hh:mm:ss</td></tr>
<tr><td>SIM_TIME_REMAIN</td><td>Displays the calculated remaining time for a Script-mode simulation (this does not reflect time inside the Interactive-mode)</td></tr>
<tr><td>SIM_BREATH_SCT</td><td>Displays the current Script file Breath and the total Breaths in the simulation (e.g. 26/134 – This is the 26th breath with a total of 134 breaths in the Script)</td></tr>
<tr><td>SIM_BREATH_CNT</td><td>Displays the total breath count including any breaths from the Interactive-mode</td></tr>
</table>

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SIM_VARFILE	Returns the path and filename of currently running vr3 file in the simulation
SW_VERSION	Displays the version number of the ASL 5000 software that is currently running (e.g. 3.5.0.46)
FW_VERSION	Displays the version number of the Firmware that is currently running on the ASL 5000 hardware unit (e.g. 4.7.76)
TAI_VERSION	Displays the version number of the Test Automation Interface that is currently running (e.g. 1.0.0.138)
TO	Time out [ms], default = 10000

Success: Return string contains the current condition of the ASL 5000 software

NOTE: All parameters EXCEPT "TO" are Read-Only

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Error Codes and Definitions

All error codes are in the following format:

!ASLXXXX: ERROR(YY) ZZ: Definition, where:

XXXX = Connected ASL 5000 (DEMO, 1234, COM1, 0000)
YY = Error code number
*ZZ = Main command that is failing**

Example error code:

>ASL0000: oa id=COM9
!ASL0000: ERROR(05) OA: INVALID PARAMTER 'ID'.
>ASL0000:

ERROR CODES

CODE	DEFINITION	EXAMPLE
01	*Unknown Error*	*TBD*
02	*Unknown Command*	*Non-command at prompt*
03	*Invalid Use of Command*	*"OA" command when ASL 5000 SW is already Running*
04	*Unknown Parameter*	*"OA blah=42" blah is unknown command*
05	*Invalid Parameter*	*"OA ID=abcd" abcd is not a valid parameter for the ID field*
06	*Temporary invalid parameter*	*User attempts to open second ASL 5000 instance of the same ID*
07	*Missing Parameter*	*"OA" without the mandatory "ID" parameter*
08	*Timeout Error*	*Command execution took longer than value of "TO"*
09	*Communications Error*	*Server cannot process incoming message*
10	*ASL 5000 Software in error state*	*Related to TC command (TBD)*
11	*Command issued before previous command completes*	*User tried to issue a command without having a prompt received before*
12	*Operation failed*	*Invalid path specified in "OA" command*
13	*File already exists / Write Error*	*Attempt to overwrite a file without permission or file not writable*
14	*File not found or cannot be read by TAI*	*Attempt to open a non-existing, protected, or corrupted file*
15	*ASL 5000 Software Closed Externally*	*Occurs when an instance of the ASL 5000 software is closed outside of using the EX command in the TAI (e.g. via Task Manager)*
16	*Cannot set parameter*	*If the user attempts to set the value of either a Read-only parameter or a parameter of the IC command that is not available for the currently used Lung Model*

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17	*Cannot get parameter*	*If the parameter is (temporarily) non-readable*
18	*Parameter out of range*	*If user tries to query breath 10 from simulation with only 8 breaths*
19	*Firmware mismatch*	*When the firmware on the ASL 5000 hardware does not match the firmware on the ASL 5000 software*
20	*Script error*	*When a script contains a non-existing .vr3 file reference*
99	*Command not part of this release*	*A known command is used which has not been implemented in the current release of the server software*

** for error 11: ZZ = 'whole ignored message'*

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